

# The Shift in Money Demand: What Really Happened?

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THE money demand function is a key relationship in conventional macroeconomic models. When it appeared that during the mid-1970s the conventional specification had undergone an unforeseen shift, analysts devoted considerable ingenuity and research effort to testing alternative explanatory variables that would account for the change.<sup>1</sup> Some specifications have produced marginally superior forecasting results. None, however, has been successful in explaining the post-1974 behavior of money demand.

Discussions of the temporal stability of parameters in econometric models generally differentiate between two distinct types of shift. One type of shift is an intercept, or level, shift, in which the estimated relationship simply undergoes a parallel change that leaves all marginal (slope) coefficients unaffected. The other type of shift occurs when at least

one of the relative slope coefficients changes. Surprisingly, previous examinations of the money demand puzzle have not explicitly investigated this basic distinction. The approach used in most previous work has been to presume that the change was not necessarily parametric, but due to the exclusion of an important variable. Hence, most studies focused on searching for the "correct" scale or opportunity cost measures to be used in the relationship.<sup>2</sup>

Given the unsuccessful nature of this approach, we consider a different tack. The purpose of this article is to study explicitly the nature of the shift in money demand. The evidence suggests that the conventional money demand specification was subject to a once-and-for-all *level* shift during the mid-1970s. Our results further suggest that the economic relationship underlying the estimated slope coefficients of the conventional equation remained remarkably stable throughout the turbulent 1960-79 period. This result conflicts directly with much previous research.

The format of the paper is as follows: First, the apparent deterioration in the standard specification for M1 during the I/1960-IV/1979 period is documented.<sup>3</sup> Then, a procedure to determine likely point(s) of intercept change(s) in the money demand function is suggested and implemented. Finally, the implications of our findings are presented.

<sup>1</sup>See, for example, Michael J. Hamburger, "Behavior of the Money Stock: Is There a Puzzle?" *Journal of Monetary Economics* (July 1977), pp. 265-88; Gillian Garcia and Simon Pak, "Some Clues in the Case of the Missing Money," *American Economic Review* (May 1979), pp. 330-34, and "The Ratio of Currency to Demand Deposits in the United States," *Journal of Finance* (June 1979), pp. 703-15; Richard D. Porter, Thomas D. Simpson and Eileen Mauskopf, "Financial Innovation and the Monetary Aggregates," *Brookings Papers on Economic Activity* (1:1979), pp. 213-29; H. Robert Heller and Mohsin S. Khan, "The Demand for Money and the Term Structure of Interest Rates," *Journal of Political Economy* (February 1979), pp. 109-29; David J. Bennett, Flint Brayton, Eileen Mauskopf, Edward K. Offenbacher and Richard D. Porter, "Econometric Properties of the Redefined Monetary Aggregates," Board of Governors of the Federal Reserve System, Division of Research and Statistics (February 1980), processed; G. S. Laumas and David E. Spencer, "The Stability of the Demand for Money: Evidence from the Post-1973 Period," *Review of Economics and Statistics* (August 1980), pp. 455-59; and Thomas D. Simpson and Richard D. Porter, "Some Issues Involving the Definition and Interpretation of the Monetary Aggregates," in *Controlling the Monetary Aggregates III*, Conference Series No. 23, (Federal Reserve Bank of Boston, 1980), pp. 161-234.

<sup>2</sup>For a critical analysis of attempts to repair the conventional specification, see R. W. Hafer and Scott E. Hein, "Evidence on the Temporal Stability of the Demand for Money Relationship in the United States," this *Review* (December 1979), pp. 3-14.

<sup>3</sup>The 1960-79 period is used to focus attention explicitly on the problems associated with money demand estimations through the mid-1970s. Estimation of the function through 1980 and 1981 would necessitate allowances for the possible effects of the credit control program and the change in Federal Reserve operating procedures. Such analysis would divert attention from the previously unresolved issue.

Table 1  
Regression Results for Equation 1

Period	Coefficient <sup>1</sup>					Summary statistics <sup>2</sup>			
	Constant	$y_t$	RCP <sub>t</sub>	RCB <sub>t</sub>	(M/P) <sub>t-1</sub>	$\bar{R}^2$	SE(x10 <sup>-3</sup> )	h	rho
I/1960-IV/1973	-0.610 (2.82)	0.125 (2.69)	-0.016 (3.02)	-0.032 (2.08)	0.778 (6.02)	0.967	3.96	1.78	0.31
I/1960-IV/1979	-0.275 (2.35)	0.057 (2.51)	-0.019 (3.45)	-0.039 (1.79)	0.962 (13.55)	0.874	5.27	-0.87	0.55

<sup>1</sup>All variables enter logarithmically. The log-level equation is estimated using Hatanaka's procedure. The numbers in parentheses are absolute values of t-statistics.

<sup>2</sup> $\bar{R}^2$  is the coefficient of determination corrected for degrees of freedom, SE is the standard error of the estimated equation, h is the Durbin h-statistic and rho is the Hatanaka estimate of the autocorrelation coefficient.

## THE SHIFT IN THE MONEY DEMAND FUNCTION: A REVIEW OF THE PROBLEM

The conventional money demand specification is

$$(1) \ln (M/P)_t = \alpha_0 + \beta_1 \ln y_t + \beta_2 \ln RCP_t + \beta_3 \ln RCB_t + \beta_4 \ln (M/P)_{t-1} + \epsilon_t,$$

where M represents the narrow definition of money (new M1),<sup>4</sup> P is the implicit GNP deflator (1972=100), y is real GNP (1972 dollars), RCP is the commercial paper rate and RCB is a weighted average of the commercial bank passbook rate. While many different money demand equations have been estimated, equation 1 is generally the standard used for comparison.

Initial estimates of equation 1 revealed a significant degree of first-order serial correlation in the error process. Previous estimates of equation 1 gen-

erally have corrected this problem through the use of the Cochrane-Orcutt iterative procedure. This approach, however, yields inefficient coefficient estimates in the presence of a lagged dependent variable.<sup>5</sup> Therefore, to obtain estimates that are (asymptotically) efficient and consistent, Hatanaka's residual adjusted Aitken estimation procedure is used in this study.<sup>6</sup>

Table 1 presents estimates of equation 1 for the I/1960-IV/1973 and I/1960-IV/1979 sample periods. The estimates for the earlier sample period are quite similar to those of other studies. These estimates suggest that real money balances adjust toward their equilibrium levels at the rate of about 22 percent per quarter, *ceteris paribus*. The esti-

<sup>5</sup>Roger Betancourt and Harry Kelejian, "Lagged Endogenous Variables and the Cochrane-Orcutt Procedure," *Econometrica* (July 1981), pp. 1073-78; and Michio Hatanaka, "An Efficient Two-Step Estimator for the Dynamic Adjustment Model with Autoregressive Errors," *Journal of Econometrics* (September 1974), pp. 199-220. It has been shown also that the Cochrane-Orcutt procedure may not iterate to a global minimum of the regression standard error. See R. W. Hafer and Scott E. Hein, "The Dynamics and Estimation of Short-Run Money Demand," this *Review* (March 1980), pp. 26-35.

<sup>6</sup>Previous money demand studies using the Hatanaka procedure include Charles Lieberman, "The Long-Run and Short-Run Demand for Money, Revisited," *Journal of Money, Credit and Banking* (February 1980), pp. 43-57; Laumas and Spencer, "Stability of the Demand for Money," and Stuart D. Allen and R. W. Hafer, "Money Demand and the Term Structure of Interest Rates: Some Consistent Estimates," *Journal of Monetary Economics* (forthcoming).

For an examination of the Hatanaka procedure vis-a-vis Cochrane-Orcutt, Hildreth-Lu and maximum-likelihood estimation techniques, see Edward K. Offenbacher, "A Comparison of Alternative Estimators of a 'Standard' Money Demand Equation," Special Studies Paper No. 157 (Board of Governors of the Federal Reserve System, July 1981).

<sup>4</sup>In response to a changing financial environment, the monetary aggregates were redefined. Thus, checkable deposits can now take the form of negotiable orders of withdrawal (NOW), automatic transfer system (ATS) and credit union share draft accounts. The old M1 measure has been augmented by the introduction of these deposits. To the extent that this empirical redefinition of the "transactions" measure of money is induced by the advent of near-money substitutes, the use of old M1 may reveal unstable relationships. Whether other financial innovations, such as money market mutual funds, repurchase agreements, overnight Eurodollars and the like, impinge upon the estimation of equation 1 is an empirical matter to be addressed below. Indeed, this line of reasoning has been used to explain the poor post-1973 performance of equation 1. See Garcia and Pak, "Some Clues in the Case of the Missing Money" and "The Ratio of Currency to Demand Deposits," and Porter, Simpson and Mauskopf, "Financial Innovation," for examples of such arguments.

mated elasticities also are similar to other estimates. For example, the estimated long-run income elasticity is 0.56, a value that roughly coincides with the theoretical value given by a simple transactions demand framework.<sup>7</sup> Finally, the summary statistics indicate that a large amount of the variation in real money balances is captured by the right-hand variables, and the error process appears well-behaved.

The regression results for the I/1960-IV/1979 period are quite unlike those of the I/1960-IV/1973 period. The estimated short-run income elasticity is halved, while the coefficient on the lagged dependent variable increases markedly. The estimated speed of adjustment (0.04 percent) from the I/1960-IV/1979 results indicates that the mean adjustment lag exceeds 26 quarters, considerably different from that for the pre-1974 period (4.5 quarters). Moreover, the estimated long-run income elasticity for the full period is now 1.50, three times the estimate obtained from the earlier sample period.

The I/1960-IV/1979 estimates seem to support the claim that the money demand relationship has been altered. The regression evidence presented in table 1 suggests that the estimated coefficients have shifted dramatically. Moreover, a standard F-test for structural stability allows one to reject the hypothesis of stable regression coefficients across the commonly hypothesized IV/1973 break point: The calculated F-statistic of 4.51 exceeds the 5 percent critical value of 2.23.<sup>8</sup>

Further evidence of the breakdown is demonstrated by an analysis of the equation's forecasting ability. Post-sample static forecasts for the natural log of real money balances are presented in table 2.<sup>9</sup> These forecasts are based on the coefficient estimates from the I/1960-IV/1973 regression. The results in table 2 indicate a continual overprediction of real money balances. The Theil bias coefficient

<sup>7</sup>See William J. Baumol, "The Transactions Demand for Cash: An Inventory Theoretic Approach," *Quarterly Journal of Economics* (November 1952), pp. 545-56; and Robert J. Barro, "Integral Constraints and Aggregation in an Inventory Model of Money Demand," *Journal of Finance* (March 1976), pp. 77-78.

<sup>8</sup>This test is complicated by the presence of first-order serial correlation. In the results reported, the serial correlation coefficient ( $\rho$ ) is allowed to vary across subperiods.

<sup>9</sup>Those familiar with the recent money demand literature may find it surprising that *static* rather than *dynamic* forecasts are employed. The latter technique yields an exaggerated picture of the shift in a relationship without proper interpretation. Consequently, the more widely understood static forecasting procedure is employed in this paper. See Scott E. Hein, "Dynamic Forecasting and the Demand for Money," this *Review* (June/July 1980), pp. 13-23.

Table 2

### Post-Sample Static Simulation Results: I/1974-IV/1979

Log-level specification <sup>1</sup>	
Year and Quarter	Forecast error (x10 <sup>-2</sup> )
1974 I	0.02
II	-1.28
III	-1.29
IV	-1.60
1975 I	-2.28
II	-0.68
III	-1.32
IV	-2.51
1976 I	-1.32
II	-1.30
III	-2.22
IV	-1.75
1977 I	-1.48
II	-2.25
III	-1.85
IV	-1.36
1978 I	-1.49
II	-2.41
III	-1.86
IV	-2.26
1979 I	-2.66
II	-1.21
III	-1.49
IV	-2.31
Summary statistics <sup>2</sup>	
RMSE	1.782 (x10 <sup>-2</sup> )
U <sup>M</sup>	0.882
U <sup>S</sup>	0.010
U <sup>C</sup>	0.109

<sup>1</sup>The forecast errors (actual less predicted) are logs of M1 (billions of 1972 dollars). They are obtained from simulating equation 1 and are based on coefficient estimates in table 1.

<sup>2</sup>RMSE is the root-mean-squared error in terms of real money balances (billions of 1972 dollars) for the log-level specification. U<sup>M</sup> is the Theil bias coefficient, U<sup>S</sup> the variance coefficient and U<sup>C</sup> the covariance coefficient. For an explanation of these statistics, see Theil, *Applied Economic Forecasting*.

(U<sup>M</sup>) indicates that almost 90 percent of the forecast error is attributable to bias, that is, one-sided prediction errors.<sup>10</sup> Moreover, the root-mean-squared error (RMSE) of 0.01782 is more than four times the in-sample standard error.

<sup>10</sup>For a complete description of the derivation and interpretation of the Theil coefficients, see Henri Theil, *Applied Economic Forecasting* (Amsterdam: North Holland Publishing Co., 1966), pp. 27-32.

## CHOOSING BETWEEN INTERCEPT AND SLOPE SHIFTS

The preceding evidence suggests that the parameter estimates of equation 1 from the 1960-79 period no longer represent a viable empirical model of short-run money demand. Obviously, "some sort of shift has occurred."<sup>11</sup> The question is, "What type of shift has occurred?" If the estimated slope coefficients have changed, this implies changes in the underlying economic relationship (i.e., between real money balances and real income or interest rates). While the estimates of the slope coefficients show marked change over the two periods in table 1, the true slope coefficients may not have actually changed. If, instead, an intercept shift occurred during the mid-1970s, then empirical estimates of equation 1 for the I/1960-IV/1979 sample period may be seriously biased because of the failure to account for the level shift in the relationship, which produces a "missing variable" problem.<sup>12</sup> Consequently, if the slope coefficient estimates are biased, they could lead a researcher to falsely reject the hypothesis of slope coefficient stability.

The major difficulty with an analysis of intercept shifts is in pinpointing exactly when the shift(s) occurred. A useful procedure to determine the likely points of an intercept or slope shift is to re-estimate equation 1 in first-difference form.<sup>13</sup> First-differencing equation 1 yields

$$(2) \Delta \ln (M/P)_t = \beta_1 \Delta \ln y_t + \beta_2 \Delta \ln RCP_t \\ + \beta_3 \Delta \ln RCB_t + \beta_4 \Delta \ln (M/P)_{t-1} + \Delta \epsilon_t,$$

where  $\Delta$  is the first-difference operator.

Equation 2 provides useful diagnostic information in the event of an intercept shift in the level equation. For example, a once-and-for-all intercept shift in equation 1 will appear as a one-time increment in the disturbance pattern of the first-difference specification.<sup>14</sup> Moreover, changes, if any, in the slope coefficients in equation 1 also will appear in

equation 2. If, as many have argued, the marginal relationships embodied in equation 1 have changed, the first-difference specification also will exhibit similar changes in the coefficient estimates. Thus, the first-difference specification serves a dual purpose: It can locate the most likely points of an intercept shift, and it provides evidence on whether the slope coefficients have changed.

To locate and test for potential intercept shifts, the following procedure was adopted: The I/1960-IV/1979 first-difference specification (equation 2) was estimated using ordinary least squares, the residuals were plotted over time and the large residual "outliers" were selected.<sup>15</sup> Based on this procedure, three points were identified and selected as candidates for points of intercept shift: II/1974, IV/1975 and II/1979. The first two residuals were negative, suggesting downshifts in the log-level money demand equation. The II/1979 residual was positive, suggesting an upshift. Equation 1 was estimated (again using the Hatanaka procedure) assuming one-time shifts at those points using (0,1) intercept dummy variables:  $D1=1$  for I/1960-I/1974, 0 otherwise;  $D2=1$  for II/1974-III/1975, 0 otherwise; and  $D3=1$  for IV/1975-IV/1979, 0 otherwise.

Preliminary significance tests revealed that only the II/1974 intercept shift term was statistically significant at the 5 percent level. Consequently, we report the version of equation 1 that incorporates

<sup>14</sup>This increment will be noticeable if the intercept shift is "sufficiently large" relative to the variance of the disturbances. Thus, the residuals of equation 2 are examined to determine the likely point at which "large" shifts occurred.

<sup>15</sup>The focus of this article concerns the possible intercept shift in the log-level money demand equation. Consequently, the reader is referred to Hafer and Hein, "Investigating the Shift in Money Demand," for a more detailed analysis of the first-difference estimation results. To give the reader some idea of the outcome, the OLS estimates of equation 2 for the I/1960-IV/1979 period are (absolute value of t-statistics in parentheses)

$$\begin{aligned} \Delta \ln (M/P)_t = & 0.190 \Delta \ln y_t - 0.017 \Delta \ln RCP_t \\ & (3.51) \quad (2.94) \\ & - 0.038 \Delta \ln RCB_t + 0.562 \Delta \ln (M/P)_{t-1} \\ & (1.68) \quad (5.70) \end{aligned}$$

$$\bar{R}^2 = 0.448 \quad SE = 0.005 \quad h = 0.47$$

Not only do the coefficient estimates appear reasonably close to the pre-1974 estimates, but *ex post* forecasts indicate a substantial improvement in the pattern. The resultant RMSE is well within two standard errors of the equation's in-sample standard error and the Theil decomposition statistics indicate that only 7 percent of the forecast error is attributable to bias. Moreover, an F-test for structural change at IV/1973 yields an F-value of 0.06.

For a discussion of these results, see Edward K. Offenbacher, "Discussion of the Hafer and Hein, Smirlock and Webster Papers," in *Empirical Studies of Money Demand*, pp. 88-106.

<sup>11</sup>Stephen M. Goldfeld, "The Case of the Missing Money," *Brookings Papers on Economic Activity* (3:1976), p. 726.

<sup>12</sup>Excluding a relevant variable, in this case the intercept shift term, may bias not only the coefficient estimates, but also the estimate of the residual variance. On this point, see G. S. Maddala, *Econometrics* (McGraw-Hill, 1977), pp. 155-57.

<sup>13</sup>A more complete discussion of this derivation appears in R. W. Hafer and Scott E. Hein, "Investigating the Shift in Money Demand: An Econometric Analysis," in *Empirical Studies of Money Demand: Proceedings of a Conference Held at the Center for the Study of American Business*, Working Paper No. 70 (Center for the Study of American Business, Washington University, August 1981), pp. 1-28.

only the II/1974 intercept shift variable (D1). The resulting coefficient estimates are (absolute value of t-statistics in parentheses)<sup>16</sup>

$$\begin{aligned}
 (3) \ln(M/P)_t = & -0.406 + 0.013 D1 + 0.076 \ln y_t \\
 & (3.95) \quad (2.88) \quad (3.83) \\
 & -0.021 \ln RCP_t - 0.020 \ln RCB_t \\
 & (4.84) \quad (1.28) \\
 & + 0.917 \ln(M/P)_{t-1} \\
 & (16.09) \\
 \bar{R}^2 = 0.960 \quad SE = 0.0048 \quad h = -0.05 \quad \hat{\rho} = 0.24
 \end{aligned}$$

These results support the contention that the marginal relationships in the short-run money demand equation were not altered as much as previous evidence suggests. The evidence, however, points to the existence of a significant, once-and-for-all downward *level* shift in the relationship in II/1974.

The regression results indicate that the constant term in the log-level specification decreased from -0.406 for the I/1960-I/1974 period to -0.419 in II/1974. This change (0.013) is small relative to the standard error of the coefficient estimate. It is, however, almost three times as large as the standard error of the regression (0.0048) for the I/1960-IV/1973 period. Thus, its exclusion significantly affects the full-sample, level estimation.

A superficial comparison of the shift-adjusted, log-level estimates with those for the I/1960-IV/1973 sample period in table 1 suggests that the slope coefficients may have changed across the period tested. The question to be addressed now is, once the downward displacement of the constant term has been accounted for, have the slope coefficients changed statistically? To formally test this hypothesis, equation 3 was re-estimated for the full sample period with the individual slope coefficients allowed to take on different values in the two separate subperiods. Zero-one dummy variables again were used to delineate the relevant subsamples (I/1960-I/1974 and II/1974-IV/1979): the dummy variables are D1=1 in I/1960-I/1974, 0 otherwise; and D2=1 in II/1974-IV/1979, 0 otherwise. The estimated equation using both the intercept and slope

dummy variables is (absolute value of t-statistics in parentheses)<sup>17</sup>

$$\begin{aligned}
 \ln(M/P)_t = & -0.482 - 0.008 D1 + 0.099 D1 \ln y_t \\
 & (2.76) \quad (0.53) \quad (2.61) \\
 & + 0.124 D2 \ln y_t - 0.018 D1 \ln RCP_t \\
 & (3.69) \quad (3.41) \\
 & - 0.013 D2 \ln RCP_t \\
 & (1.76) \\
 & - 0.019 D1 \ln RCB_t \\
 & (1.39) \\
 & - 0.015 D2 \ln RCB_t \\
 & (0.15) \\
 & + 0.832 D1 \ln(M/P)_{t-1} \\
 & (7.45) \\
 & + 0.560 D2 \ln(M/P)_{t-1} \\
 & (2.77)
 \end{aligned}$$

$$\bar{R}^2 = 0.969 \quad SE = 0.0044 \quad DW = 1.90$$

Standard t-tests were used to test the hypothesis that *each* slope coefficient had remained stable *once the downward level shift in II/1974 had been taken into account*. The resulting t-statistics indicate that each coefficient had *not* changed statistically over the full-sample period. The variables and the t-statistics for their coefficients are  $\ln y$  (0.43),  $\ln RCP$  (0.19),  $\ln RCB$  (0.03) and  $\ln(M/P)_{t-1}$  (1.35). This evidence supports the view that money demand was subject to a level not a slope shift during the mid-1970s.<sup>18</sup>

## CONCLUSION

The purpose of this article has been to investigate the nature of the shift in the conventional money demand specification that occurred during the mid-1970s by determining whether it was an intercept or slope shift. The empirical results presented in this article indicate that the conventional equation was subject to a level, and *not* a slope, shift in early 1974. Our analysis of the first-difference results and the

<sup>16</sup>The use of the dummy variable for the I/1960-I/1974 period and the constant term is interpreted in the following manner: The true constant term for the I/1960-I/1974 period is obtained by adding the estimated constant and the estimate on the dummy variable. The constant for the II/1974-IV/1979 period is represented by the estimate of the constant term reported in the text.

<sup>17</sup>Since the Hatanaka procedure requires estimation of the residual error in the last-stage equation, it, too, was constrained in the above manner. A test revealed that neither the error process nor  $\rho$  had changed. This procedure, in conjunction with the dummy variable test, precludes obtaining a direct estimate of  $\rho$ .

<sup>18</sup>If the preceding evidence were not sufficient to sway the skeptical reader, more support comes from the shift-adjusted, log-level equation's *ex post* forecasting record: The RMSE for the shift-adjusted equation for the period II/1974-IV/1979 is 0.67 ( $\times 10^{-2}$ ). This value is well within two standard errors of the estimating equation's in-sample standard error, and is less than half the RMSE reported in table 2 ( $1.782 \times 10^{-2}$ ).

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properly specified log-level equation suggests that II/1974 is the most likely point of the significant downward shift in the money demand function.

An important implication of this study is that the economic relationships inherent in the conventional money demand function are more stable than previous investigations have suggested. Changes in money demand since II/1974 can be explained by changes in the exogenous variables without relying on tenuous assertions that the underlying economic relationships have degenerated. Although previous analyses have suggested that there has been a con-

tinuous, unexplained deterioration of the money demand function after 1973, our analysis suggests that the marginal relationships have remained stable over the I/1960-IV/1979 period, providing useful information in estimating the level of money demand.<sup>19</sup> Thus, claims that the short-run money demand function is highly unstable and is responsible for the erratic behavior of money growth during this period must be reconsidered.

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<sup>19</sup>For example, see Stephen H. Axilrod and David E. Lindsey, "Federal Reserve System Implementation of Monetary Policy: Analytical Foundations of the New Approach," *American Economic Review* (May 1981) pp. 246-52.